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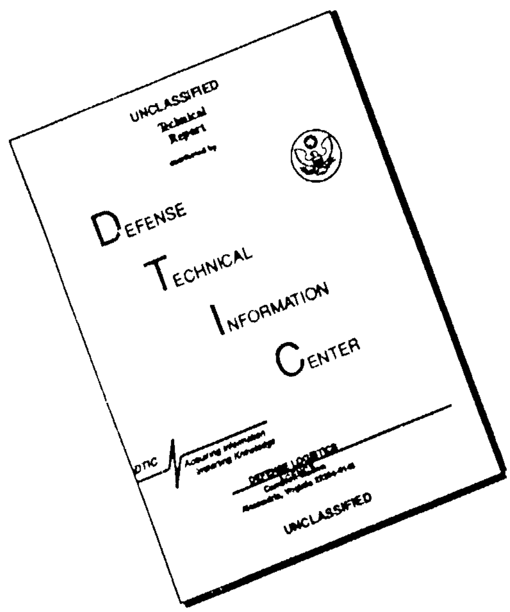

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TECHNICAL NOTES NO. FRL-TN-27

THE DEVELOPMENT OF THE LINED HOLLOW CHARGE

DIPL ING RUDOLF THOMANEK, BINDLACH UBER BAYREUTH

MARCH 1961

319 700

TRANSLATED BY SP6 ALEX PALINKAS

FROM EXPLOSIVSTOFFE, V. 8, NO. 8 (1960)

AUGUST 1960

FELTMAN RESEARCH LABORATORIES
PICATINNY ARSENAL
DOVER, N. J.

COPY

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THE DEVELOPMENT OF THE LINED HOLLOW CHARGE

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In the present contribution, the discovery of the so-called lining effect and the beginning of the development of the lined hollow charge will be described.

A previous submission of the contents of this paper to the Reich Chancellery resulted in a formal presentation on 12 December 1935 before responsible representatives of the Army Ordnance Office (Captain Wimmer, First Lieutenant Schwenninger).

The 30 and 35 mm steel plates made available for this purpose by the WA Proving Field 1 could not be penetrated by shooting but were penetrated by placing the charges on the plates. Privately undertaken trial shots heretofore were not able to penetrate steel plates but only up to 12 mm boiler plate. This 12 mm boiler plate was penetrated without difficulty so that the participants believed the question of detonation to be solved. However, this was not as simple as was believed at that time. The firing plunger that led axially through the cavity from the tip of the round to the detonator cap at the bottom did not disturb the unlined hollow charge too much, but apparently the transmission time was too long, so that the lead was demolished by the impact. The effectiveness of the cavitation must have been strongly impaired.

The development in 1936 was in the hands of the responsible officials only, without the participation of the industry. The Army Ordnance Office, Proving Field 1, developed from a smoke shell the 7.5 cm (75 mm) Projectile 38 with a pressed explosive charge that, in accordance with the test and research work by Ordnance Office F (Dr. Trinks), led to cylindrical cavity with an attached hemisphere. The aluminum sheet part placed in the cavity served as a thin wall to shield the explosive material without reducing its effectiveness.

In this round, a small spin-safe impact detonator was used (AZ 33) with a duplex capsule for firing through flash tube running from the tip of the round to the detonator in the base of the round. The shell was available for use at the beginning of the war (WW II) as armament for the short tank gun. With this shell it was possible, without regard to distance, to penetrate 35 mm armor, a performance that can be duplicated by classical armor-piercing shell only at close range.

Dr. Wuelfken, Government Surveyor of Works in the Engineer Section of Ordnance Office, Proving Field 6, developed at about the same time the 12.5-kg bell charge and the 50-kg split charge as an HL demolition block for breaching armored domes. Such unlined charges were used among others in taking the Eben-Emanuel fortifications.

The author resumed his studies of ballistics and explosives chemistry during the spring of 1936 at the TH (Technical high school) in Berlin. In 1937, he was taken by Dr.-Ing. Thome into the then under construction Institute K of the Space Travel Research Institute in Braunschweig, where he could transfer his plans into actual tests.

Beginning with the conception that the cloud of gas produced by the detonations enters the cavity with growing speed, a number of measures were to be tried to increase the kinetic energy of such gas clouds. Among these measures were:

Enlarging the gas clouds by mixing lead oxide and carbon.

Reconstruction of the detonation wave to concave wave forms that would reach if possible all parts of the cavity at the same time (through explosive hemispheric shells that could be set on the explosive charge).

Spacious cumulative initiation through hollow explosive spheres.

Raising the gas cloud speed through evacuation of the cavity.

Through a vacuum trial with a glass body imbedded in explosive, the author discovered the lining effect on 4 February 1938.

In the beginning, the true explanation for the phenomenon was naturally not known and it was supposed that the effect was due to the vacuum. However, a few control trials at various levels of vacuum disclosed that the vacuum does not have any measurable influence, but that the glass wall in the explosive is responsible for producing the much greater depth of penetration. In this connection, the 1950 trials conducted by the United States with evacuated cavity charges led to particle speeds of 90 km/sec instead of the usual 8 to 10 km/sec.

Compared in Figure 3 are the 3 basic forms of the explosive charges, (a) without a cavity, (b) with an unlined cavity, and (c) with the lined cavity. The explosion occurs on poured Silumin blocks. The massive charge achieves 12 mm penetration depth, the unlined cavity charge 52 mm, and the glass cone charge 128 mm. The rise in effectiveness was so surprising that the author suspected a flaw in the ingot, primarily because the hole was small and full of fissures.

This effect must have surprised the technical world, since it could be assumed that a complete filling of the cavity with inert material would have to result in less success than would be achieved with the massive explosive bodies pictured in Figure 3 (a). One would have supposed that the reduction of the amount of materials in the cavity toward emptiness would produce a steady rise in effectiveness toward that of a normal hollow charge.

Should one plot the ratio of the weight of the explosive material to the lining weight G_S/G_A as abscissa and the depth of penetration as ordinate, then curve 1 (Fig 4) corresponds to the expected results. Actually, starting with $G_A = 0$, the best results are achieved by increasing the lining weight (i. e., wall thickness) up to a maximum, as shown in curve 2 (Fig 4).

The value G_S/G_A is smallest for a given explosive body when the whole cavity is filled with the inert material G_A. Under this arrangement, the effect on the support is practically nil. On the other hand, G_S/G_A goes toward infinity when G_A approaches zero. The penetration depth corresponds, in this border case, to that of the normal hollow charges without lining.

So many factors affect the dimensions of the lining that the formulation of exact procedures is avoided and the technician is advised only that such a maximum effectiveness exists. After a few trials the appropriate lining for the explosive body in question can be found. Difficulties in defining the lining will be found since all linings for the securing of the cavity have been patented (in Germany in 1910 and Great Britain in 1911 by, respectively, the owner Wasag and the inventor Neumann). The author has demonstrated to the patent office various hollow charges with the variously described linings according to the text and drawings of the Neumann patent.

This was an attempt to prove whether the rise in effectiveness failed in linings made in accordance with the patents. Important as far as the appearance of the curve is concerned, this is possible by very thick as well as very light metal lining. Paper, leather, etc., according to the British patents, have no effect.

Nowhere in the literature was there any reference to a rise in lining effectiveness. The HWA (Army Ordnance Office), in spite of their familiarity with the Neumann patents, did not recognize the effectiveness of such a lining, although the 7.5 cm HL shell in production had an aluminum lining to protect the explosive charge.

Since the linings in the trial explosives made in accordance with specifications of the patent office did not have any influence when a thinner sheet was used and had an adverse effect when thicker inserts were tried, the author and his coworker Brandmayer secured a secret

patent (Number 188/43, dated 9 December 1939) in which the requirements under the express headings of cone, hemisphere, and bell form state:

1. Explosive projectile, in whose explosive charge a cavity has been formed to increase the explosive effectiveness, characterized by a lining of the cavity. The penetration of the charge is equal to that of an unlined charge weighing at least 5 times as much.

2. A projectile with an explosive charge as defined in 1. above in a design identified by the lining of the cavity with brass.

(Retranslation of Royal Hungarian Patent 134,378 given on 9 December 1943 based on German patent priority of 9 December 1939).

This patent, whose scope of protection was so extensive that it covered all hollow charges with a rising effectiveness of lining, became closed in addition to 80 patents and reports purchased by the German Reich, while Hungary received from the author the secret patent, and Japan the right to produce the "Panzerfaust" (an antitank weapon) and the "Panzerschreck."

The meaning of the discovery for the war effort is known. It led to the development of modern armor-piercing weapons, that would be unthinkable without the lined hollow charge.

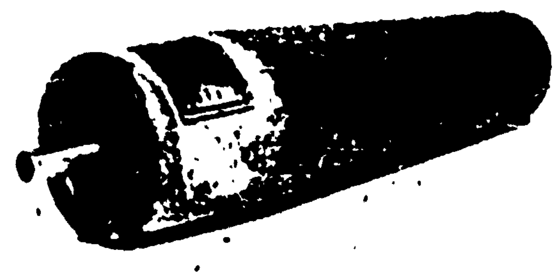

Fig 1

Fig 2

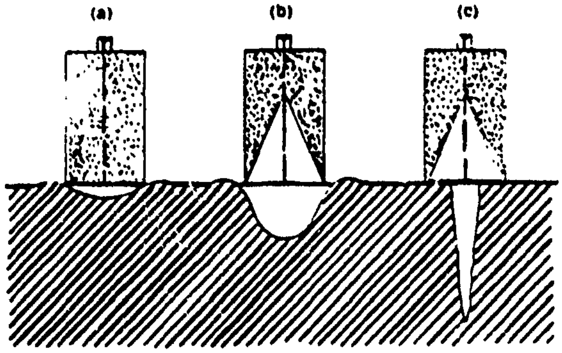

Fig 3

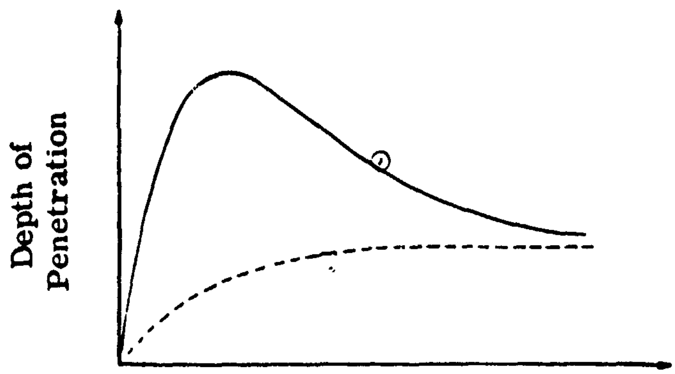

Fig 4
Weight of Explosive
Lining Weight

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